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THE USE of RADIUM in CONSUMER PRODUCTS

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THE USE of RADIUM in CONSUMER PRODUCTS

by

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FOREWORD

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The Medical and Occupational Radiation Program is the component of the Center which deals with reduction of unnecessary radiation exposure of patients, workers, and others incidentally exposed by the use of X-rays, radioactive materials, radiopharmaceuticals, and particle accelerators.

The Center publishes its findings in Radiological Health Data and Reports (a monthly publication), the Environmental Health Series, Public Health Service numbered reports, appropriate scientific journals, and Program and Branch technical reports.

The technical reports of the Medical and Occupational Radiation Program (MORP) allow comprehensive and rapid reporting of the results of inhouse and contractor projects. The reports are distributed to State and local radiological health program personnel, Center technical staff, Center advisory committee members, University radiation safety officers, libraries and information services, industry, hospitals, laboratories, schools, the press, and other interested individuals. These reports are included in the collections of the Library of Congress and the Clearinghouse for Federal Scientific and Technical Information.

I encourage the readers of these reports to inform the Center of any omissions or errors. Your additional comments or requests for further information are also solicited.

James G. Terrill

James G. Terrill, Jr.
Center Director

PREFACE

This report discusses the extent of the use of radium in products available to the public. It is an attempt to consolidate information pertaining to these products so that their potential health implications can be put into perspective.

Since 1916, when radium luminous compounds were first available, radium has been used in a large variety of products intended for use by the general public or specialized groups. These include radium activated self-luminous timepieces, instruments and markers, fire detection devices, static eliminators, electron tubes and various gaging devices. Consumer items containing radium have not only been sold through normal commercial channels, but have also been distributed through the government surplus disposal program. Many of these items are not labeled as being radioactive.

Although less hazardous radioisotopes are undoubtedly replacing radium in consumer products, the fact that the use and application of radium is unregulated in many States may encourage its continued use in such products. A greater awareness is needed to protect the public from potential exposure to consumer products containing radium. The extent and hazards of the use of these products should be understood by all public health agencies.

John C. Villforth
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INTRODUCTION

About 1916 the first timepieces having luminous dials and hands painted with radium were manufactured. This utilization of radioactive material in a consumer product, which preceded the use of reactor-produced radioactive materials by almost half a century, held forth a promise of widespread use in an almost unlimited number of commercial applications. An article in Scientific American of April 24, 1920, states that more than 4,000,000 watches and clocks alone had been produced which utilized this "new and mysterious form of energy" (*1*). The article lists the following items incorporating radium luminous compounds at that time: house numbers, keyhole locators, ships' compasses, telegraph dials, mine signs, steam gages, pistol sights, poison bottle indicators, bedroom slipper buttons, furniture locator buttons, theater seat numbers, automobile steering-wheel locks, luminous fishbait, and glowing eyes for toy dolls and animals. All of these items were produced and sold with no effort on the part of government or industry to protect the consumer or the worker from the hazards of radium. Today, fifty years later, there is still no uniform government control over the production and use of consumer products containing radium. This contrasts sharply with efforts by the Atomic Energy Commission (AEC) to control consumer products containing other radioactive materials, some of which are less hazardous than radium.

Not only was radium used indiscriminately to produce luminosity in consumer items, but it was also used in medical and medical-related "quack" devices and applications which were available to the public. Although it has long been recognized that such applications and devices have no therapeutic value, they are still being uncovered even today. For example, a bottle of homeopathic radium bromide tablets was discovered in a New Jersey hospital pharmacy in December 1965. The radium content of the tablets, though quite low, presented a needless radiation hazard. Subsequently, two homeopathic pharmacies were identified as having made drugs from naturally-occurring radioactive materials. One of the pharmacies still had these drugs in stock. Other examples are the radium "crocks" and "cones" which were advertised as cure-alls for all types of human illness. These contain radium salts or radium-bearing ores and are intended to "charge" drinking water with radon. Each year these devices are discovered in basements, attics, antique stores, etc. A manufacturer in Florida was producing such devices as late as 1965.

This report discusses the public health aspects and implications of the use of radium in consumer products. Devices which cannot be classed as consumer products, yet are readily available to relatively untrained or unsuspecting individuals, are also discussed. Selected photographs of devices containing radium appear in the appendix.

HAZARDS OF CONSUMER PRODUCTS CONTAINING RADIUM

Luminous Timepieces

There is currently no reliable information available concerning the number of timepieces with radium luminous dials and hands which have been produced or imported, and sold in the United States in the past nor is information available as to the number of such timepieces now in circulation or produced annually. However, several studies in foreign countries have attempted to estimate the use of radium luminous timepieces and the resulting genetically significant dose to the population (*2-7*). McCarthy found that 61 percent of the adult males and 9 percent of the adult females wore such watches in Denmark (*2*). He calculated that the genetically significant dose to the Danish population in 1961 was 1.2 millirems a year, which is 1.2 percent of the natural background radiation dose (*8*). The British Medical Research Council estimated the genetically significant dose in Britain to be approximately one percent of the natural background (*4*). The highest reported estimate of genetically significant dose (Switzerland) is 3.3 percent of the natural background (*7*). Table 1 tabulates the available estimates of genetically significant dose from luminous watches.

One major factor in estimating the genetically significant dose from radium luminous timepieces is the radium content of the timepiece. This content will depend on many factors such as size of hands and dials, radium concentration in the luminous paint, etc. Thus radium content will vary considerably, as indicated by many investigators (*2,3,5,7,9*). An excellent summary of some of these investigations is given by Seelentag, who found reported average values of radium content ranging from a low of 0.014 µg to a high of 0.36 µg; individual values were found up to almost 5 µg of radium (table 2) (*5*).

Table 1. Estimated genetically significant dose from radium in self-luminous timepieces

Source of estimate	Country	Year of report	Use distribution		Estimated annual genetic dose (millirems)
			Males	Females	
McCarthy (*2*)	Denmark	1961	61%	9%	1.2
Joyet (*7*)	Switzerland	1960	66%	25%	3.3
Seelentag (*6*)	Germany	1959	-	-	2.6
Seelentag (*5*)	Germany	1961	-	-	1.5
Medical Research Council[a] (British)(*4*)	Great Britain	1960	3×10^6	1×10^6	0.5-1.0

[a]Only data on the estimated total number of males and total number of females wearing radium activated self-luminous timepieces were given in reference (*4*).

Table 2. Radium content of men's wristwatches (*5*)

Author - Locality	Year of report	Radium equivalent (μg)	
		Average value	Range
British Medical Research Council	1956	0.2	
Glaser - Schramberg	1957	0.035	0.030-0.042
	1958	--	0.045-0.100
Joyet - Zurich	1958	0.36	0.060-0.810
	1960	0.144	0.106-4.460
Flatby & Koren - Oslo	1959	0.19	
Seelentag & Klotz - Germany	1959	0.04	0.008-0.095
Seelentag & Schmier - Germany	1961	0.014	0.002-0.885

The gonadal dose from a wristwatch containing 1 μg of radium has been measured as well as calculated (table 3). For a person who wears the watch 24 hours a day, this dose will be between 65 millirems and 130 millirems each year or approximately 65 to 130 percent of the annual genetic dose from natural background radiation. Therefore, the genetic dose resulting from the use of a radium activated self-luminous timepiece can be a significant fraction of the genetic dose from natural background radiation.

The exposure to the forearm per microgram of radium in wristwatches has been estimated to be as high as 800 percent of the extremity dose limit for individuals in the population (table 3). Thus the local dose to the forearm from a high radium content watch can approach or exceed the population dose limit. Population dose limits as recommended by the International Commission on Radiological Protection are given in table 4 (*10*).

Table 3. Radiation dose from wristwatches of different activities (5).

Author	Activity (μg radium equivalent)	Annual gonadal dose		Annual dose to forearm	
		mrems	Percent of natural radiation[a]	mrems	Percent of MPD[b]
Seelentag & Klotz, 1959	0.04	5.3	5.3	2,600	34
Seelentag & Schmier, 1961	0.014	1.8	1.8	850	11
(minimum value)	0.002	0.3	0.3	122	2
(maximum value)	0.885	115	115	54,000	720
Flatby & Koren (day & night use)	0.19	23	23	--	--
Flatby & Koren (daytime use only)	0.19	4.4	4.4	--	--
Joyet (men's watches)	0.14	9.8	9.8	--	--
Joyet (ladies' watches)	0.06	3.9	3.9	--	--
Joyet (maximum value)	4.5	310	310	270,000	3600
For comparison and correlation against other activities:					
Seelentag	1.0	130	apprx. 130	60,000	800
Flatby, 24 hours	1.0	120	apprx. 120		
Flatby (days only: 16 hours)	1.0	23	apprx. 23		
Joyet (men's watches)	1.0	70	apprx. 70		
Joyet (ladies' watches)	1.0	65	apprx. 65		

Note: Doses of Seelentag and co-workers are calculated, and those of Flatby and Koren, as well as Joyet, measured on wearers of watches which had up to 100 times the activity of normal illuminated dials.

[a]Background genetic radiation dose is taken as 100 millirems a year (8).
[b]Maximum Permissible Dose for the forearm (population) = 7.5 rems = 7,500 mrems per year.

Table 4. ICRP recommended dose limits for individuals in the population (*10*)

Organ	Annual dose (rems)
Gonads and total body	0.5
Blood-forming organs and lens of eye	0.5
Thyroid and skin	3
Bone[a]	3/n
Hands and forearms; feet and ankles	7.5
Other organs	1.5

[a]The "n" referred to is defined as the "relative damage factor." It is unity for radium isotopes and for gamma radiation; it is set equal to 5 for all other radionuclides in bone.

The National Center for Radiological Health has investigated the gonadal dose from the use of radium activated self-luminous pocket watches. A group of such watches, which were removed from government surplus channels, were examined (see Government Surplus). The radium content of 18 of these watches, selected at random, ranged from 0.60 to 1.39 µg, with an average of approximately 1 µg. A simulated watch was prepared by attaching calibrated radium needles behind the crystal of one of the watches after the hands and dial had been removed. This watch was placed with its crystal facing inward on the crest of the iliac of a sectioned human phantom. Lithium fluoride thermoluminescent dosimeter rods inserted in various anatomical sites within the phantom were used to measure the dose from the watch. The annual dose to the testes was calculated to be 60 mrems per µg of radium, based on a wearing period of 16 hours daily.

Most radium dial wristwatches can be produced with a radium content of less than 0.1 µg. Only in special types of watches, such as those worn by skin divers, can a radium content in excess of this value be justified. Unfortunately, the maximum permissible radium content of timepieces has not been established in the United States either by recommendation or by law. The European Nuclear Energy Agency (ENEA) and the International Atomic Energy Agency (IAEA) have adopted "Radiation Protection Standards for Radioluminous Timepieces" (*11*). These standards limit the radium per wristwatch to an average of 0.1 µg and a maximum of 0.15 µg. Clocks are allowed a maximum of 0.2 µg and special timepieces a maximum of 1.5 µg of radium (table 5). Also, the use of radium activated self-luminous pocket watches is not recommended. These standards could be voluntarily adopted by United States manufacturers of timepieces, but there is no Federal legislation which could be used to require the implementation of these ENEA/IAEA standards. Some States have established legal authority to regulate the manufacture of radium luminous timepieces through licensing and New York City required a permit for possession of such timepieces under certain conditions (*12*). These States could adopt ENEA/IAEA standards, or similar standards for radium, but Federal enforcement would require new legislation.

Table 5. Recommended average and maximum limits for radionuclide content of radioluminous timepieces[a]

Type of timepiece	Radionuclide					
	^{3}H(mCi)		^{147}Pm(μCi)		^{226}Ra (μCi)	
	Average	Maximum	Average	Maximum	Average	Maximum
Wristwatch	5	7.5	100	150	0.1	0.15
Pocket watch	5	7.5	100	150	Not recommended	
Clocks	7.5	10	150	200	0.15	0.2
Special timepieces	--	25	--	500	--	1.5

[a] Recommendations of the European Nuclear Energy Agency and the International Atomic Energy Agency (*11*).

Luminous Markers, Instrument Faces, Dials, and Component Parts

Radium has been extensively used to provide luminosity for a large variety of instruments. The aircraft industry and the military have been primary users of these luminous devices. Many hundreds of thousands have been produced. For example, the U.S. Army recently disposed of 70,000 wrist compasses which contained radium luminous faces and pointers. Of these, thirty thousand had been distributed for use since 1958, while 40,000 had been stored in Army depots around the country.

Radium luminous position indicators have been used on knobs, switches, etc. Luminous markers using radium have also been used extensively on aircraft, ships and submarines. The major manufacturer of luminous markers used several hundred grams of radium in production for the armed forces during World War II. Even today some of the specifications for military procurement may require radium as the activating agent in self-luminous devices.

Although luminous markers, instrument faces, dials, and component parts were produced primarily for the aircraft industry and the military, they find their way into consumer outlets as government surplus.

Other Devices

In addition to items containing radium which are available to the general public for personal use, there are many products used in business and industry which employ radium in their operation or function but which are not generally considered primarily as radium sources. For example, radium has been used or is being used in laboratory balances, fire detection devices, static eliminators, and in gages for determining density, thickness, moisture, etc. These devices are often used by individuals who are unaware that the device contains radium and are usually untrained or unprepared to cope with the actual or potential hazard. Table 6 lists some of these devices.

Similar types of devices using radioactive materials which are regulated by the AEC are "generally licensed" or exempted. These devices must be manufactured under a specific license but may be possessed by an individual without the need to obtain a specific license. Such devices are, therefore, manufactured in such a way as to minimize the potential hazard to the user and are properly labeled before they can be sold. Periodic leak testing of the device may be required. However, except in Agreement States* and New Jersey, radium has not been subjected to these stringent controls. In Agreement States, compatibility must be maintained with the AEC in terms of program and standards. Since most Agreement States apply to radium the same standards they apply to the "agreement materials," uniform standards for radium can be maintained among these States. However, there are only 19 such States at the present time and there is no reason to believe that all States will become Agreement States in the immediate future. Only two to four States a year have entered into such agreements since Kentucky signed the first State-AEC agreement in 1962.

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*Note: An Agreement State is a State which has entered into an agreement with the Atomic Energy Commission under Section 274 of the Atomic Energy Act, whereby certain of the Atomic Energy Commission's authority for the control of radioactive material is transferred to the State.

Table 6. Devices containing radium

Type of device	Quantity of radium per device
Gages	
Moisture	1-10 mg (Ra-Be)
Density	1-10 mg
Thickness	10-100 µg
Level	1-10 mg
Vacuum	100-400 µg
Static Eliminators	
Industrial	3 mg max. (25-50 µg/inch)
Laboratory balances	6-20 µg
Fire Detection	.1-40 µg
Chromatography	50-100 µg
Electron Tubes	.1-10 µg

GOVERNMENT SURPLUS

Government surplus property is disposed of through the General Services Administration (GSA) and the Defense Supply Agency (DSA). Disposal is handled by the 10 GSA Regional offices and 25 Defense Surplus Sales offices. Surplus property is generally disposed of on a bid or auction basis. Hundreds of retail surplus stores purchase these items and sell them directly to the public.

Government surplus items are not generally labeled to indicate the presence of radium. Consequently, large quantities of such items may be stocked in retail surplus stores with little or no suspicion of actual or potential hazard to store employees or customers. For example, in 1964 the California Department of Public Health conducted a survey of 37 retail surplus stores in four major California population centers (*13*). Twenty of these stores stocked items containing radioactive material. Most stores had fewer than fifty such items; however, one store had several thousand switches, circuit breakers, meters, etc. containing radium luminous paint. Surveys revealed that external radiation levels in areas of some stores were high enough to require that the areas be designated "controlled areas" under California regulations for radiation control. It was also noted that almost all the stores would require a specific license from the California Department of Public Health if these regulations were strictly enforced, since the amount of radioactive material on hand exceeded the exempt or generally licensed quantities. Neither the presence of the radioactive material nor the licensing requirements were known to the store owners. The report of the survey concluded that the Federal government should institute effective procedures to keep items containing radioactive material out of the consumer market.

In 1965, the National Center for Radiological Health became directly involved in the problem of radium in government surplus items through its efforts to eliminate radium luminous compound kits from the inventory of GSA. Four GSA warehouses which stocked these items were surveyed for contamination and external gamma radiation levels. As a result, the National Center for Radiological Health disposed of 300 luminous compound kits.

In 1968, the National Center for Radiological Health was instrumental in preventing the distribution of 3,154 government surplus pocket watches containing radium and had disposed of 1,700 of these at the time of this report.

Although government surplus items which are not labeled with regard to the radium content are probably not a major health hazard, the hazard is sufficient to warrant more effective control efforts.

Table 7. Comparison of radiation characteristics of promethium-147, tritium, and radium (*16*)

Characteristic	Promethium-147	Tritium	Radium-226
Half-life	2.5 years	12.3 years	1,620 years
Radiation emitted	Beta particles only - 0.226 MeV maximum energy, 0.063 MeV average	Beta particles only - 0.018 MeV maximum energy, 0.005 MeV average	Alpha particles - 24 MeV per Ra disintegration, in equilibrium with 5 alpha-emitting daughters; Beta particles - about 4 per Ra-226 disintegration with maximum energies 0.65, 2.3, 0.017, and 1.17 MeV; Gamma rays - about 2.29 photons per Ra-226 disintegration, with energies ranging from 0.184 - 2.2 MeV, averaging 0.78 MeV.
Range of radiation in tissue	0.049 cm - maximum energy beta particle	0.0006 cm - maximum energy beta particle	0.5 cm - maximum energy beta particle; 10 inches - average penetration of gamma rays (range is infinite)
Maximum permissible continuous body burden (NBS Handbook 69) (*15*)	0.06 millicurie	1 millicurie	0.0001 millicurie
Effective half-life	570 days (bone)	12 days (total body)	1.6×10^4 days (bone)
Dose from single intake by inhalation of ENEA/IAEA recommended maximum total activity of wristwatches (*11*) (table 5)	30 rems to bone from 150 µCi soluble Pm-147 10.5 rems to lung from 150 µCi insoluble Pm-147	1.8 rems to whole body from 5 mCi soluble H-3 75 rems to lung from 5 mCi insoluble H-3	35 rems to bone from .15 µCi soluble Ra-226 19.5 rems to lung from .15 µCi insoluble Ra-226

THE CHALLENGE FROM BYPRODUCT MATERIAL

Although information is incomplete, it appears that less hazardous byproduct materials are replacing radium in those consumer products which have a large market, such as luminous timepieces. For example, tritium and promethium-147 are being used in ever greater quantities as radium substitutes in luminous products. This may be reflected to some extent in the increased sale of tritium by the AEC from 60,000 curies in 1963 to 178,874 curies in 1967 (*14*). Tritium or promethium persents less external gamma radiation hazard to the consumer than radium. A comparison of the radiation characteristics of these radionuclides is given in table 7 (*16*). The estimated annual dose to the critical organs of an individual wearing a wristwatch containing the ENEA/IAEA recommended maximum quantities of radium and promethium (table 5) are shown in tables 8 and 9, respectively (*11*).

The conversion to the use of less hazardous radioisotopes in consumer products could reflect some concern on the part of industry for the reduction of radiation exposure to the public. However, the conversion has not been complete and there are no Federal statutes that require the use of less hazardous radioisotopes in consumer products of domestic or foreign manufacture.

In many States, radium may be used in a product without even State or local governmental control over the manufacturer or the user. This lack of control may induce some manufacturers to use radium in new products or to continue to use it in established products. Federal control of radium could eventually result in the total replacement of radium in consumer products by much less hazardous radioisotopes.

Table 8. Annual radiation dose received by critical organs from wristwatch containing 0.15 µg radium-226 (*11*)

Organ	Type of irradiation	Annual dose received (rems)
Lens of the eye (3 mm deep)	beta	0.11[a]
Skin of the face	beta	0.40[a]
Blood-forming tissues (trunk)	gamma	0.03[b]
Skin of the wrist (at 1.5 cm)	gamma	4.8[c]

[a]Value determined experimentally.
[b]Calculated value.
[c]Calculated value. The maximum permissible dose to the extremity for individual members of the population is 7.5 rems each year (table 4).

Table 9. Evaluation of possible radiation dose from wrist-watches containing 150 μCi of promethium-147 (*16*)

Body part	Basic assumption	Estimated maximum annual dose (rems)	ICRP annual limit for body part (rems)
Wrist	Worn continuously, back surface of watch contacting wrist	1,314	7,500
Lens of eye	Within 20 cm of eye 4 hours/day	56	500
Gonads	Within 50 cm of gonads 24 hours/day, shielded by 10 cm of unit density tissue	2.7	500
Skin	Crystal contacting skin of body 1 hour/day	548	3,000

[a]See table 4.

THE OCCUPATIONAL HAZARD: RADIUM VERSUS BYPRODUCT MATERIAL

The occupational hazard of the use of radium has long been known. Much of current knowledge about the effects of radioactive material deposited in the human body is based on studies of the early radium dial painters (*17*). Since the hazard of radium dial painting became known, conditions have greatly improved in the luminising industry in the United States as well as abroad (*18*). Today there is reason to believe that the body burden of luminisers who work with radium luminous paint rarely exceeds the maximum permissible body burden. However, Vennart reports one English tritium luminising factory in which tritium levels in workers frequently exceeded the maximum permissible body burden (*19*). He claimed that workers in this plant objected to urinalysis used in determining tritium body burden. He also reported that some English factories were abandoning the use of tritium in favor of radium in self-activated luminous products because whole body counting or radon breath analysis used in radium bioassay is less objectionable and need be repeated less frequently.

The observations of Vennart apply only to England; the extent of their applicability to this country is unknown to the author. However, the National Center for Radiological Health has conducted and has participated in studies of watch and instrument repair shops where radium luminous hands, dials, and paints are handled. The Center is also conducting a study to assess tritium hazards in a major luminising plant.

In 1966, the Oklahoma Department of Health and the National Center for Radiological Health conducted a cooperative study of watch repair shops in Oklahoma. This study included 225 repair shops (about 75 percent of the total in the State). However, no watch manufacturers or major dial refinishing shops were included. Based on information supplied by the repair shops, the study indicated that approximately 200,000 luminous dial watches were repaired per year in the facilities surveyed (this number probably includes light-activated and tritium-activated luminous dials, since it is generally not possible to differentiate these from radium-activated luminous dial watches without survey instruments). About 70 percent of the facilities painted timepiece hands with premixed wax base radium paint. An estimated 14,000 pairs of hands were painted per year. Approximately 10,000 pairs of hands and essentially all the dials requiring refinishing were sent to custom finishing shops for painting with luminous compound. Radioactive contamination was found in essentially all of the shops surveyed; in 70 percent of the facilities the maximum total alpha contamination observed on the benches exceeded 1,000 dpm/$100cm^2$. In about 12 percent of the shops the removable alpha contamination exceeded 100 dpm/$100cm^2$. Contamination levels of 1000 dpm/$100cm^2$ total alpha and 100 dpm/$100cm^2$ removable alpha are frequently used in the nuclear industry as contamination limits and are used here only as a reference to the degree of contamination observed in the watch repair shops. In nuclear facilities stringent radiation protection procedures are followed, whereas in watch repair shops workers frequently smoke and eat at the work bench, thus risking ingestion of radioactive material.

The National Center for Radiological Health has been involved in studies of radium contamination in aircraft instrument repair shops in Kansas and Florida (*20*). The radium contamination in these facilities largely results from the repair and rehabilitation of surplus government instruments with radium dials. The individual facilities are not refinishing radium dial instruments with self-luminous paint but are only utilizing the instruments for repair parts. In some cases these instruments are used for original installation in light aircraft. In general, these facilities take no specific precautions with regard to radiation protection, and the fact that the instrument contains radioactive material is incidental to normal procedures.

The Eberline Instrument Corporation and the Kansas State Department of Health surveyed 14 aircraft instrument repair facilities in the Wichita, Kansas area under PHS contract. In five of these facilities, contamination levels exceeded 200,000 dpm/100cm^2 total alpha. Whole body counting of 33 individuals included in the survey showed that two individuals contained radium body burdens which were approximately 40 percent of the maximum permissible body burden. The study indicated that approximately 5 percent of the instruments being repaired in the Wichita area contained radium.

A similar study was performed in Miami, Florida by the Dade County Health Department in cooperation with the National Center for Radiological Health. Contamination levels in the 15 facilities surveyed were found to be lower than those in Wichita by a factor of 10 or more. This may be attributed to the fact that these shops primarily service instruments for commercial airlines; these instruments rarely contain radioactive luminous compounds. Radium body burdens were not determined for individuals from these facilities.

The Southeastern Radiological Health Laboratory of the National Center for Radiological Health is currently conducting a study of tritium hazards in a factory which produces luminous dials and hands. Urine samples taken in this study show that most of the employees have tritium body burdens approaching the recommended maximum permissible body burden (*21*). Some have body burdens several times the permissible level. The extent of this problem in the tritium luminising industry is not yet known. Consequently, the Laboratory plans to expand the study to include other tritium luminising facilities.

SUMMARY AND CONCLUSIONS

Since 1916 radium has been used in a wide range of products available to the public. The predominant use of radium has been as the activating agent in self-luminous compounds applied to timepieces, instrument hands and dials, knobs, controls, switches, markers, etc. Other devices containing radium include gages for moisture, density, and thickness; fire detection devices; static eliminators; electronic tubes; and chromatographs.

The radiation dose to the United States population from the use of products containing radium is not known, although studies in other countries indicate that the genetically significant dose to the population from radium luminous timepieces may range from one to three percent of that due to natural background radiation. However, an individual's forearm could receive a radiation dose which approaches or exceeds the maximum permissible population dose for extremities, if he wore a wristwatch with a radium content as large as the maximum observed in certain studies.

There is no Federal agency with jurisdiction over all manufacture and distribution of potentially hazardous products containing radium. In addition, the Federal government has in some instances increased the potential hazard through the government surplus program, by releasing to the public large numbers of unmarked or unlabeled devices containing radium.

Available information indicates that less hazardous radioisotopes are replacing radium in self-luminous compounds, as well as in other products. However, conversion to these radioisotopes is not likely to be complete in the immediate future. Since radium is relatively unregulated in many States, with respect to both the occupational hazards and the hazards to the consumer, it may remain attractive to some manufacturers.

The extent of radium use and the magnitude of its potential hazards in products available to the public are not fully known. Nonetheless, the available facts indicate the need for Federal action to bring about effective national control of such products.

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APPENDIX

(SELECTED PHOTOS)

Figure 1. Homeopathic powder and tablet preparations obtained from a homeopathic pharmacy in Pennsylvania. Dilution factors imply exponential dilutions, *e.g.*, "6x" means 10^6.

Figure 2. The "Revigator" is an example of crocks manufactured in the early 1900's for producing radon-charged drinking water, which supposedly had the same beneficial aspects as hot springs or health spas. The crock was produced from radium-bearing ores and has an exposure rate of 14 mR/hour at the surface.

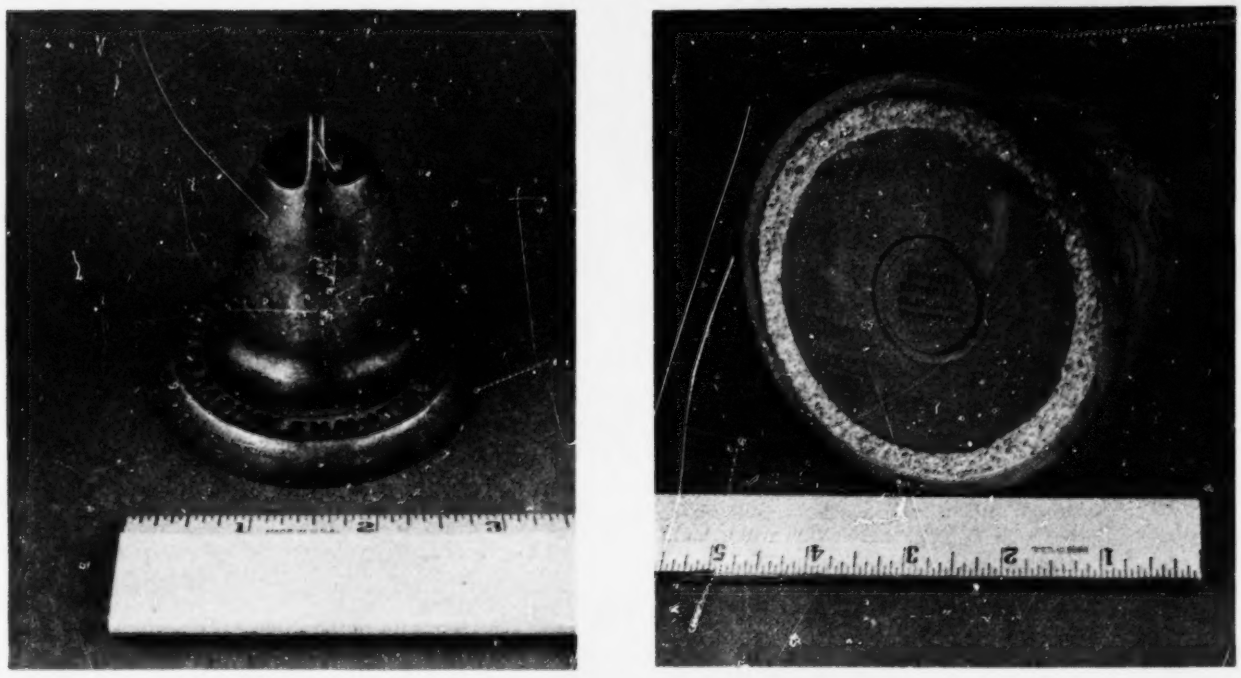

Figure 3. Examples of radium "cones" and "emanators" used to produce radon-charged drinking water. The Zimmer Laboratory radium emanator (upper left) contains, according to the manufacturer, 50,000 Mache units, which is equivalent to 18.2 mCi radon in solution.

Figure 4. The "Q Ray - Electro Radio-Active Dry Compress," or heating pad, is another example of a quack device which utilizes radium. The exposure rate at contact is 15 mR/hour.

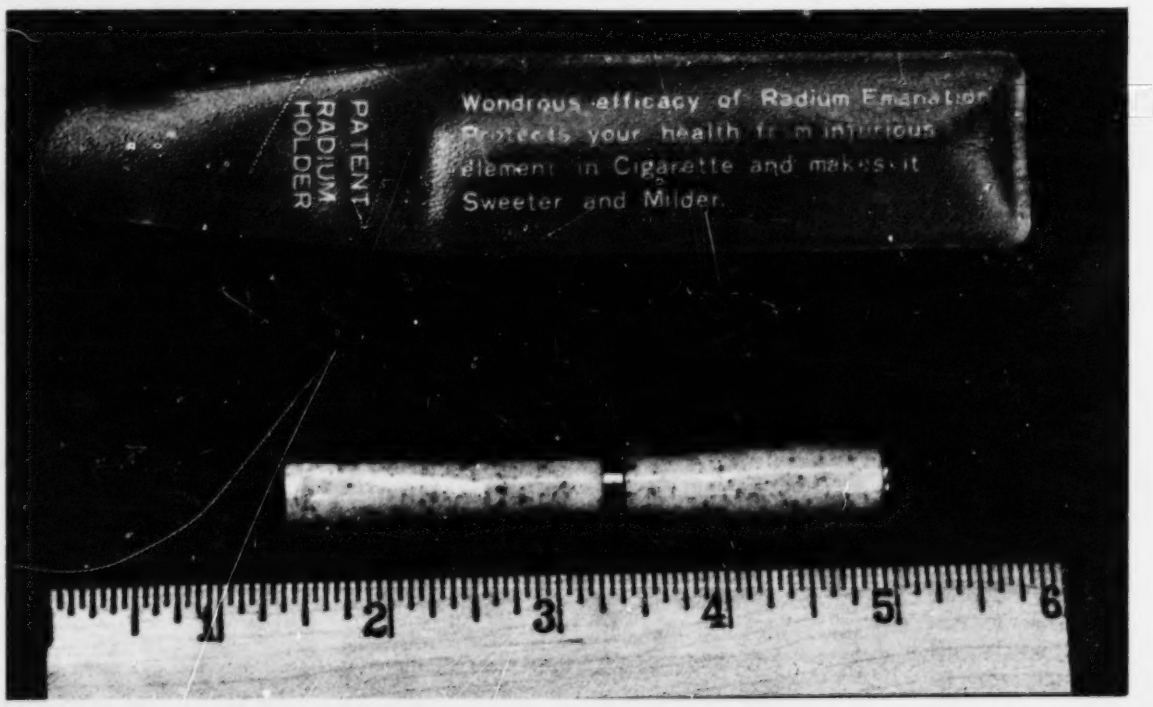

Figure 5. In 1964, advertising literature for the Lifestone (radium) Cigarette Holder claimed that it filtered the smoke through a fine powder containing radium, and would thus diminish nicotine, make tobacco sweeter and milder, "protect users from lung cancer, promise them beautiful faces and excellent health, finally rejuvenating users." Laboratory measurements showed a radioactive content slightly greater than background.

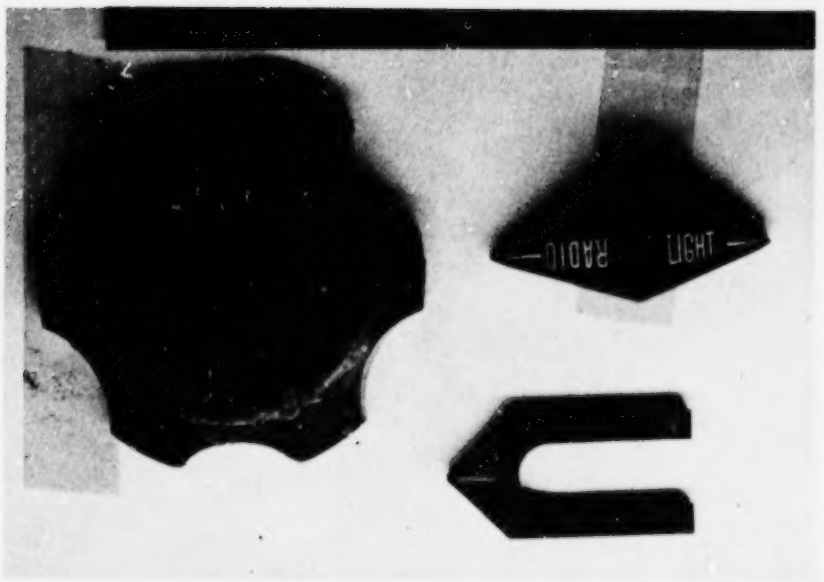

Figure 6. Military surplus items which contain radium activated self-luminous paint. The item on lower right is a gunsight.

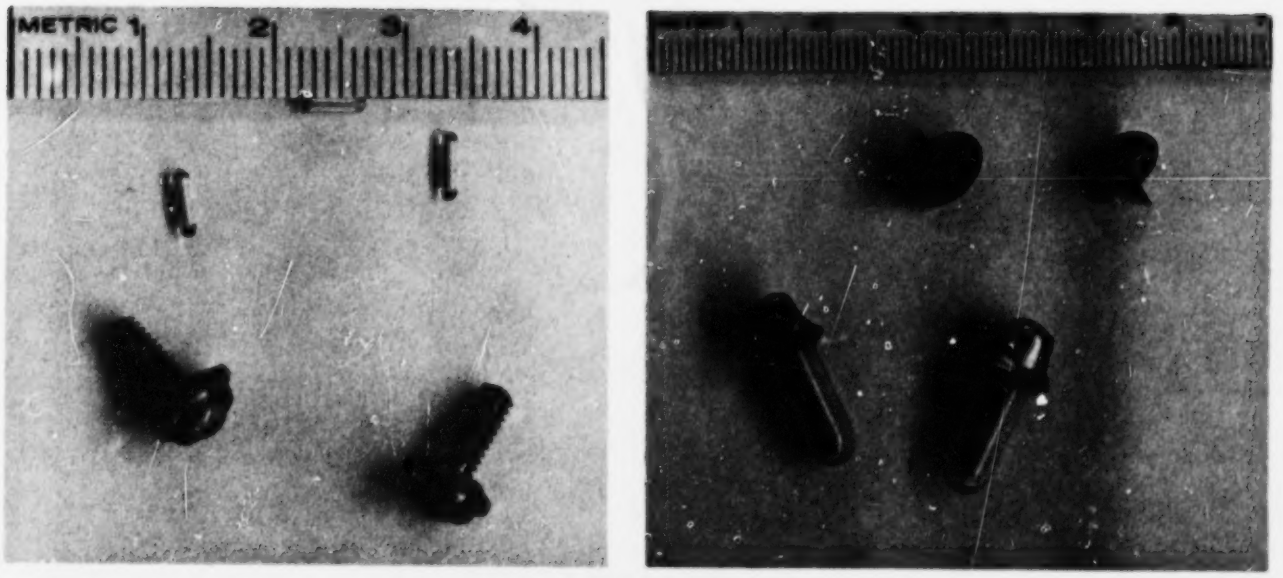

Figure 7. Self-luminous screw heads, glass vials and marker buttons, all containing radium.

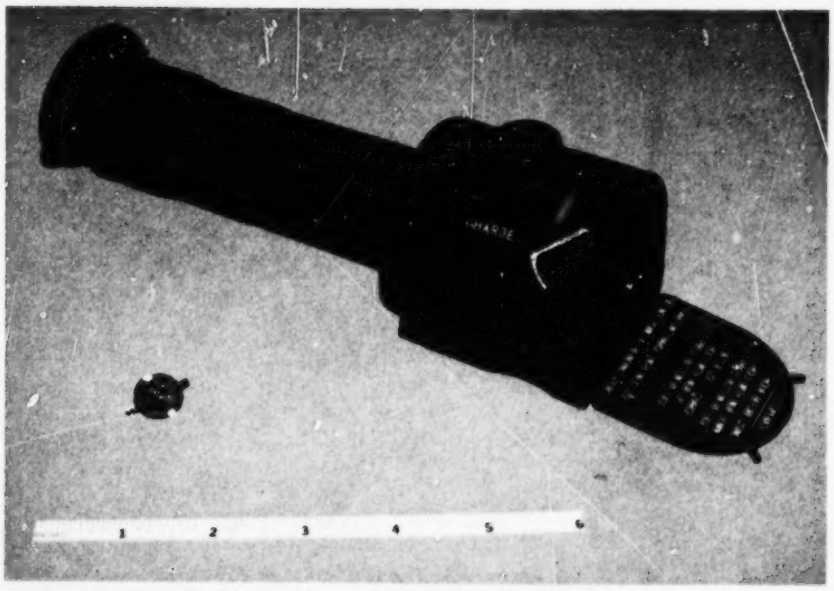

Figure 8. Infrared gunsight which employs radium. The radium is plated on a gold foil backing which is shown here removed from the gunsight.

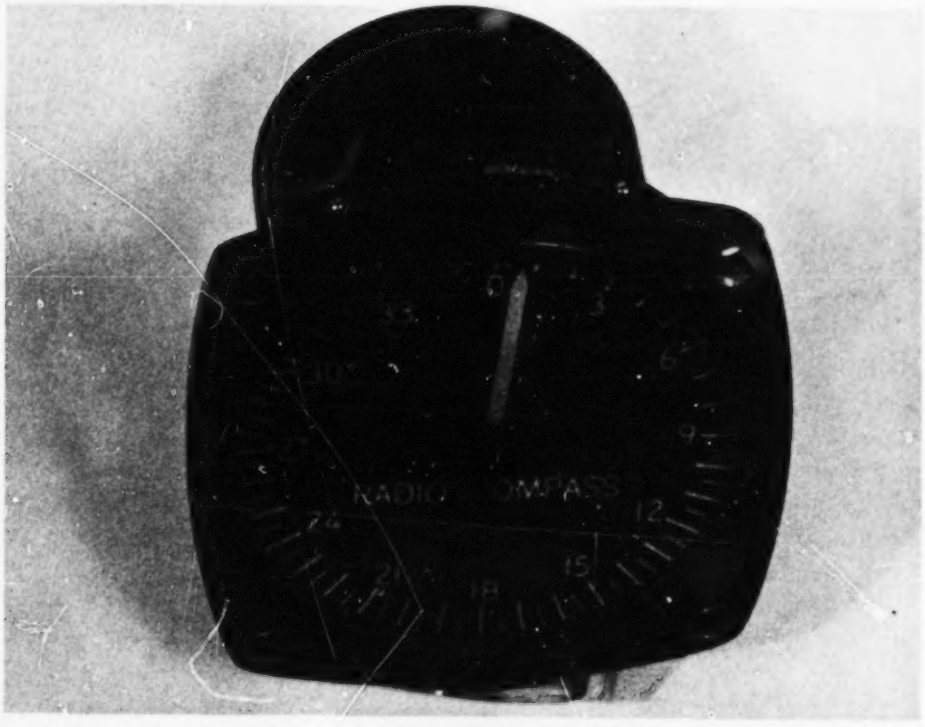

Figure 9. Radium activated self-luminous surplus military aircraft instrument.

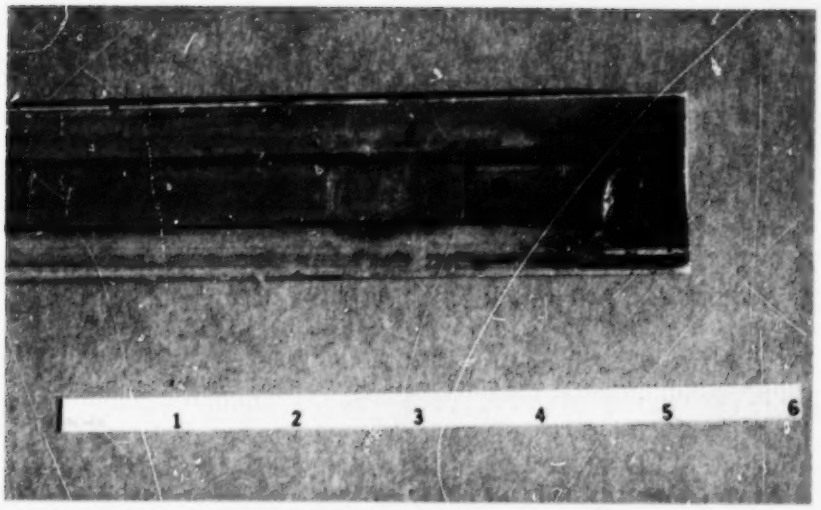

Figure 10. Portion of an industrial static eliminator bar. The bar is fabricated by depositing radium on a metal plate and covering the radium with thin metal foil (seen in center). In this instance, the entire bar is 6 feet long.

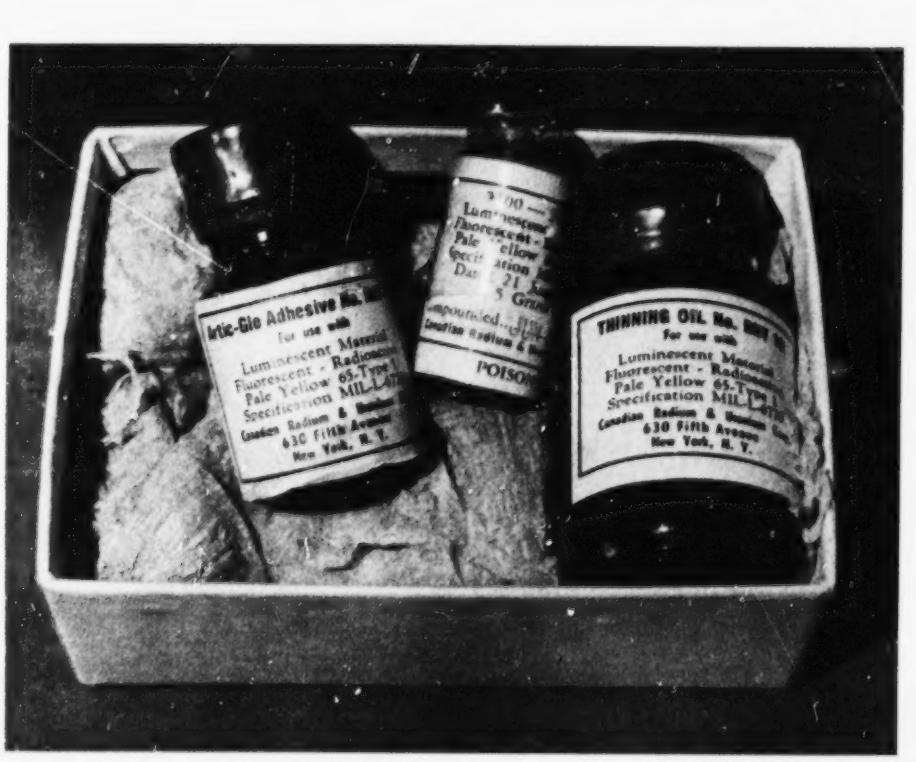

Figure 11. One of 300 radium luminous compound kits removed from government surplus distribution channels by the National Center for Radiological Health.